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# Cash flow, investment, and investment opportunities: New tests using UK panel data

by

Robert E. Carpenter<sup>a,\*,+</sup>

<sup>a</sup> *Department of Economics, University of Maryland at Baltimore County, 1000 Hilltop Circle, Baltimore, MD 21250, USA; and Federal Reserve Bank of Richmond*

and

Alessandra Guariglia<sup>b</sup>

<sup>b</sup> *School of Economics, University of Nottingham, University Park, Nottingham, NG7 2RD, UK*

## Abstract

The interpretation of the correlation between cash flow and investment is controversial. Some argue that it is caused by financial constraints, others by the correlation between cash flow and investment opportunities that are not properly measured by Tobin's  $Q$ . This paper uses UK firms' contracted capital expenditure to capture information about opportunities available only to insiders and thus not included in  $Q$ . When this variable is added in investment regressions, the explanatory power of cash flow falls for large firms, but remains unchanged for small firms. This suggests that the significance of cash flow stems from its role in capturing the effects of credit frictions.

**Keywords:** Investment, Tobin's  $Q$ , Cash flow, Financial constraints.

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\* Corresponding author.

E-mail addresses: bobc@umbc.edu (Robert Carpenter); alessandra.guariglia@nottingham.ac.uk (A. Guariglia).

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## 1. Introduction

The relationship between investment and cash flow has had a turbulent history. It was widely studied in the 1950s and 1960s (Meyer and Kuh, 1957; Kuh, 1963, etc.) Yet cash flow subsequently all but disappeared from the investment literature until its revival in the 1980s following the development of models of asymmetric information, and an empirical breakthrough in 1988 by Fazzari, Hubbard, and Petersen (hereafter FHP). FHP (1988) estimated investment equations as a function of Tobin's  $Q$  and cash flow using firm-level data<sup>1</sup>. They found that cash flow tends to have a bigger effect on the investment of firms more likely to face financial constraints and interpreted this as evidence for the existence of information-driven capital market imperfections. A large literature on the relationship between cash flow and investment followed FHP's (1988) paper, many adopting similar techniques (see Hubbard, 1998; and Bond and Van Reenen, 2005, for surveys).

The reasons why cash flow matters for investment, however, remains controversial. Some researchers have argued that instead of being caused by financing constraints, the relationship between cash flow and investment could stem from the correlation between cash flow and omitted or mis-measured investment opportunities that are not captured by standard measures, particularly Tobin's  $Q$  (hereafter  $Q$ )<sup>2</sup>. Several attempts have been made at constructing alternative measures of investment opportunities to test whether, once these opportunities are more adequately measured, cash flow still has a significant effect on firms' investment (see Gilchrist and Himmelberg, 1995; Erickson and Whited, 2000; Bond and Cummins, 2001; Bond et al., 2004; and Cummins et al., 2006)<sup>3</sup>.

The use of  $Q$  is based on the idea that investment opportunities, which are forward looking, can be captured by equity market participants, who are also forward looking. In particular, securities' prices and therefore financial markets' evaluations of investment prospects are a keystone in papers based on the  $Q$ -theory. However, in the presence of information asymmetries in capital markets, a tension is immediately introduced by the use of  $Q$ . In such circumstances suppliers of external funds are unable to accurately assess firms' investment opportunities, and it is likely that there will be gaps in the information sets of the

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<sup>1</sup> As marginal  $Q$  is not observable, it is generally proxied with average  $Q$  in empirical work. Hayashi (1982) illustrates the conditions under which the two measures are equivalent.

<sup>2</sup> As discussed in Bond and Cummins (2001) and Bond et al. (2004), this could happen if the Hayashi (1982) conditions are not satisfied or if  $Q$  is affected by measurement error, in the sense that stock market valuations are influenced by factors other than the present discounted value of expected future profits (e.g. bubbles).

<sup>3</sup> It has also been pointed out that holding constant investment opportunities, cash flow and investment could be linked because managers tend to use internal funds for non-value-maximizing projects. This is the "free cash flow hypothesis" (see Jensen, 1986; and Hubbard et al., 1995).

firm's insiders and outsiders<sup>4</sup>.  $Q$  will thus only capture outsiders' evaluation of opportunities. It is possible that cash flow significantly affects investment simply because it is correlated with the insiders' evaluation of opportunities, which are not captured by  $Q$ .

The principal contribution of this paper is to clarify the role of cash flow in investment equations by introducing, alongside  $Q$ , a new proxy for expectations reflecting the firms' insiders' evaluation of opportunities, namely the firm's contractual obligations for future new investment projects. This variable should contain information about managers' forecasts of investment opportunities. To ensure that we capture information that is not contained in  $Q$  as well, we use  $Q$  at the beginning of the period, but contracts for future investment in the period when they are announced. Including both  $Q$  and contracted capital expenditure in our investment equations improves the degree to which investment opportunities are measured. If cash flow still plays a significant role on firms' investment, then we can be more confident it is because of the role it plays in capturing the effects of credit frictions.

Another interesting aspect of our work is its contribution to the debate on the effects of financial constraints on investment, with a focus on the UK rather than the US. This is important because researchers debating the interpretation of cash flow tend to make use of US data more often than European data<sup>5</sup>.

We use a panel of 693 UK firms over the period 1983 to 2000 to estimate investment regressions distinguishing firms into more and less likely to face financial constraints using employees as a measure of size<sup>6</sup>. We initially regress investment on  $Q$  and cash flow, and find that, although cash flow affects investment of both types of firms, its effect is stronger for small firms. We then add, alongside  $Q$ , our variable measuring the firm's contractual obligations for future new investment. This ensures a more comprehensive measurement of investment opportunities. When this new variable is introduced, the explanatory power of cash flow falls for large firms, but remains unchanged for small firms. This suggests that at least for the latter, the significance of cash flow in investment equations is likely to be caused by information asymmetries in the capital markets.

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<sup>4</sup> An important theoretical paper serving as the foundation for the financing constraints literature, Myers and Majluf (1984), uses this argument to motivate the information asymmetries.

<sup>5</sup> Devereux and Schiantarelli (1990); Blundell et al. (1992); Bond and Meghir (1994); and, more recently, Bond et al. (2003, 2004) looked at the effects of financial constraints on investment in the UK. For studies focusing on firm investment and monetary policy transmission in the Euro area, see Chatelain et al. (2003), and Part II of Angeloni et al. (2003).

<sup>6</sup> Size is widely used in the literature as a criterion to partition firms into more and less likely to face financing constraints (see for instance Devereux and Schiantarelli, 1990, Carpenter et al., 1994, 1998, etc.).

The rest of the paper is laid out as follows. Section 2 summarizes the main points of controversy about cash flow's role in determining firms' investment. Section 3 illustrates our baseline specification and estimation methodology. Section 4 describes our data and presents some summary statistics. Section 5 presents our econometric results. Section 6 concludes.

## **2. Why does cash flow matter for investment? Summary of the principal points of the controversy**

The tight relationship between internal funds and investment is well known. As early as 1957, Meyer and Kuh stressed the importance of financial variables for investment and firms' seeming preference for internal funds. Research examining how firms' financing choices affected their investment was shelved in the 1960s, following the work by Modigliani and Miller (1958) and the extensive development of neoclassical models of investment (e.g., Jorgenson, 1963; Hall and Jorgenson, 1967). The  $Q$ -theory of investment (Tobin, 1969; Hayashi, 1982) can be seen as a reformulation of the neoclassical theory, according to which investment demand can be explained by the ratio between the market value of the firm's capital stock and its replacement cost. Neither the neoclassical nor the  $Q$ -theory recognised any role of financial variables in determining investment.

The importance of how investment is financed was revived with the development of theoretical models of asymmetric information. Akerlof's (1970) landmark study on the role of asymmetric information in the market for "lemons" broke with established economic theory by illustrating how markets malfunction when buyers and sellers operate under different information sets. Researchers recognised that similar arguments could be applied to firms seeking funds from lenders (e.g., Stiglitz and Weiss, 1984).

In 1988, Fazzari, Hubbard and Petersen published an influential paper which had a significant methodological impact. They abandoned the representative firm assumption, and, using firm-level US data, examined differences in the sensitivity of investment to cash flow across groups of firms more or less likely to face financial constraints. This methodology allowed them to distinguish between different potential roles of cash flow. In particular,  $Q$ , which they included in their investment regressions as a proxy for firms' investment opportunities, might not properly measure them. If this were the case, they argued, then the coefficients on cash flow could be biased due to the correlation between cash flow and investment opportunities, but one would expect the effects of cash flow on investment to be approximately equal for all groups of firms.

Alternatively, cash flow could affect investment because capital markets are imperfect, and internal finance is cheaper than external finance. In this case, one would expect cash flow to play a stronger role on the investment of firms more likely to face financial constraints. Looking at the difference in the size of the cash flow coefficients for firms more and less likely to face financial constraints would therefore provide useful evidence about the existence of financial constraints.

FHP (1988) divided firms according to dividend policy, with high-dividend firms assumed less likely to face financial constraints. Their findings showed that cash flow tends to affect the investment of low-dividend firms significantly more than that of high-dividend firms, supporting the hypothesis that cash flow affects firms' investment because of capital market imperfections.

Almost immediately, research began to address the potential shortcoming of  $Q$  as measure of investment opportunities. One branch of literature "departed from the strategy of using proxies for marginal  $Q$  and relied on the Euler equation describing the firm's optimal capital stock to model the investment decision" (Hubbard, 1998, p. 209). In the absence of financial constraints, the standard Euler equation derived under the assumption of perfect capital markets should hold. In the presence of financial constraints, on the other hand, the standard Euler equation is mis-specified as financial variables belong in it. Whited (1992), Hubbard et al. (1995), and Ng and Schaller (1996) estimated the standard Euler equation and an Euler equation augmented with financial variables for various categories of firms. Using US data, they found that the standard Euler equation generally holds only for firms less likely to face financial constraints. Bond and Meghir (1994) reached a similar conclusion using UK data.

Another branch of literature attempted to identify the effect of capital market imperfections on investment without using  $Q$  as a measure of investment opportunities, but using alternative measures of investment fundamentals. For instance, Gilchrist and Himmelberg (1995) estimated a set of VAR forecasting equations for a subset of information available to the firm, and subsequently evaluated a linear expectation of the present discounted value of marginal profits, which they used as a measure of firms' investment opportunities<sup>7</sup>. They then estimated regressions of investment on the latter variable and cash flow. Since the informational content of cash flow as a forecasting variable is built in this new measure of investment fundamentals, if the coefficient on cash flow remains significant

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<sup>7</sup> Also see Gilchrist and Himmelberg (1999).

once the new variable is included in the investment regression, it is an indication of the presence of capital market imperfections. According to their results based on US data, the neoclassical model (without cash flow) only holds for firms less likely to face financial constraints, whereas cash flow significantly enters the regressions of constrained firms. These findings are in line with those in FHP (1988)<sup>8</sup>.

An important challenge to the findings in FHP (1988) came from Kaplan and Zingales (1997). These authors focused on the low-dividend sub-sample of firms used in FHP (1988) and reclassified these firms on the basis of their degree of financing constraints, using information contained in the firms' annual reports as well as management's statements on liquidity. They found that investment of firms that appear less financially constrained is more sensitive to cash flow than investment of other firms and concluded that higher sensitivities of investment to cash flow cannot be interpreted as evidence that firms are more financially constrained. A heated debate followed the publication of Kaplan and Zingales' (1997) article: FHP (2000) criticized Kaplan and Zingales' (1997) classification scheme as flawed in identifying both whether firms are constrained and the relative degree of constraints across firm groups; Kaplan and Zingales (2000) responded to these criticisms; examining a large cross-section of firms, Cleary (1999) measured financing constraints by a discriminate score estimate from several financial variables, and supported Kaplan and Zingales' (1997) results; and Allayannis and Mozumdar (2004) showed that the results in Kaplan and Zingales (1997) and Cleary (1999) are largely caused by financially distressed firms (such as firms with negative cash flow) and/or outliers<sup>9</sup>.

A further challenge to FHP (1988) came with Bond and Cummins (2001), Bond et al. (2004), and Cummins et al. (2006), who used firm-specific earnings forecasts from securities analysts to construct more accurate measures of the fundamentals that affect the expected returns on investment. In their investment specifications, they found that if one controls for expected profitability by using I/B/E/S analysts' earnings forecasts, then the correlation between investment spending and cash flow disappears in all sub-samples of firms<sup>10</sup>. Similar

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<sup>8</sup> Past this point, the controversy on how to interpret the role of cash flow appeared to simmer for a time, as the research agenda pursued how financing constraints affected different measures of firm activity including inventory investment (Carpenter et al., 1994, 1998; Guariglia and Schiantarelli, 1998; Guariglia, 1999, 2000; and Benito, 2005); employment (Nickell and Nicolitsas, 1999); and R&D (Himmelberg and Petersen, 1994; and Bond et al., 1999).

<sup>9</sup> Using international data, Cleary (2006) supported Kaplan and Zingales' (1997) findings. Yet, Islam and Mozumdar (2007) found that the distortionary effect of negative cash flow observations reported for US data by Allayannis and Mozumdar (2004) also extends to international data.

<sup>10</sup> As pointed out in Carpenter and Guariglia (2007), however, firms selected for coverage by I/B/E/S analysts are not random, and are likely to be relatively profitable firms in industries of interest to I/B/E/S customers.

results were obtained by Erickson and Whited (2000) who regressed investment on a measure of  $Q$  adjusted for measurement error, and cash flow<sup>11</sup>.

These challenges to the findings in FHP (1988) suggest that the controversy on what might cause the observed correlation between investment and cash flow has not been resolved.

### 3. Baseline specification and estimation methodology

Our baseline specification can be represented by the following Equation:

$$I_{it}/K_{i(t-1)} = a_0 + a_1 I_{i(t-1)}/K_{i(t-2)} + a_2 Q_{i(t-1)} + a_3 CF_{it}/K_{i(t-1)} + \text{error term} \quad (1)$$

where  $I$  is the firm's investment;  $K$ , the replacement value of its capital stock;  $Q$ , Tobin's  $Q$ ; and  $CF$ , the firm's cash flow<sup>12</sup>. The subscript  $i$  indexes firms, and  $t$ , time, where  $t=1983-2000$ . Subsequently, we will add the contracted capital expenditure to capital stock ratio ( $CONK$ ) as an additional regressor to this specification, and interact all regressors with dummy variables indicating whether firms are more or less likely to face financing constraints.

We initially estimate Equation (1) using an Ordinary Least Squares (OLS) estimator. Yet, OLS estimates are likely to suffer from biases due to unobserved firm-specific heterogeneity, as well as possible endogeneity of the regressors. We therefore also present estimates obtained using a Within Groups estimator, which only account for the former bias<sup>13</sup>; estimates obtained using a pooled Instrumental Variables (IV) estimator, which only accounts for the latter bias; and estimates obtained using a Within Groups IV estimator, which accounts for both biases. Finally, we present estimates obtained using the first-difference GMM estimator, proposed by Arellano and Bond (1991), which also controls both for unobserved firm-specific heterogeneity and for the possible endogeneity of the regressors,

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Firms facing financing constraints are less likely to be followed by I/B/E/S analysts. This might explain why authors that used earning forecasts by I/B/E/S analysts as measures of investment opportunities did not find significant effects of cash flow on investment.

<sup>11</sup> Gomes (2001) provides a theoretical challenge to the hypothesis that a significant coefficient on cash flow in an investment reduced-form regression can be seen as an indication of the existence of financial constraints (also see Abel and Eberly, 2002, 2004; Alt, 2003; Cooper and Ejarque, 2001, 2003; and Moyen, 2004).

<sup>12</sup> It is common practice in the literature to include in investment equations  $Q$  evaluated at the beginning of the period and cash flow evaluated at the end of the period (see Fazzari et al., 1988; Kaplan and Zingales, 1997 etc.).

<sup>13</sup> For panels where the number of time periods is relatively small, the estimates obtained using the Within Groups estimator are inconsistent, as the transformed lagged dependent variable and the transformed error term are negatively correlated. This is generally referred to as the Nickell (1981) bias.



but which is typically more efficient than the Within Groups IV estimator. Specifically, we can rewrite a more general version of Equation (1) as follows:

$$y_{it} = \alpha y_{i(t-1)} + \beta' X_{it} + v_i + v_t + v_{jt} + e_{it}, \quad (2)$$

where  $y$  is the investment to capital ratio, and  $X$ , our set of explanatory variables (including Tobin's  $Q$  and cash flow, but excluding the lagged dependent variable). The error term in Equation (2) is made up of the following components:  $v_i$ , which denotes a firm-specific component (encompassing any permanent additive measurement error);  $v_t$ , which represents a time-specific component (that we account for by including time dummies in all our specifications);  $v_{jt}$ , which represents an industry-specific time effect (that we account for by including time dummies interacted with industry dummies in all our specifications)<sup>14</sup>; and  $e_{it}$ , which is an idiosyncratic component.

The GMM panel estimator relies on first-differencing the estimating equation to eliminate the firm-specific fixed effect, and uses appropriate lags of the right-hand side variables as instruments. As can be seen from the following Equation, first-differencing (2) allows us to eliminate the firm-specific effect,  $v_i$ :

$$\begin{aligned} y_{it} - y_{i(t-1)} = & \alpha(y_{i(t-1)} - y_{i(t-2)}) + \beta'(X_{it} - X_{i(t-1)}) + (v_t - v_{t-1}) + \\ & + (v_{jt} - v_{j(t-1)}) + (e_{it} - e_{i(t-1)}) \end{aligned} \quad (3)$$

Yet, in order to estimate Equation (3), instrumentation is still necessary to deal with the possible endogeneity of the regressors, and with the correlation between  $(y_{i(t-1)} - y_{i(t-2)})$  and  $(e_{it} - e_{i(t-1)})$ . Assuming that  $e_{it}$  is not serially correlated and that the regressors contained in  $X$  are weakly exogenous (meaning that they are uncorrelated with future realizations of the error term), the GMM first-difference estimator uses the following moment conditions:

$$E[y_{i(t-s)}(e_{it} - e_{i(t-1)})] = 0 \text{ for } s \geq 2; t = 3, \dots, 18 \quad (4)$$

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<sup>14</sup> We include time dummies interacted with industry dummies, since there could be shifts in investment demand or expectations due to changes in industry-level conditions, such as industry demand shocks, or industry-wide technology changes (see Carpenter and Petersen, 2002). The dummies are aimed at controlling for those industry-specific shifts in investment demand or expectations, and are included in addition to the standard time dummies defined at the aggregate level, which remove cyclical variation common to the entire manufacturing sector. Firms are allocated to one of the following seven industrial sectors: metals, metal goods, other minerals, and mineral products; chemicals and man made fibres; mechanical engineering; electrical and instrument engineering; motor vehicles and parts, other transport equipment; food, drink, and tobacco; textiles, clothing, leather, footwear, and others (Blundell et al., 1992).

$$E[X_{i(t-s)}(e_{it} - e_{i(t-1)})] = 0 \text{ for } s \geq 2; t = 3, \dots, 18 \quad (5)$$

These moment conditions imply that values of  $y$  and of all the  $X$ s lagged twice or more can be used as instruments in our regressions. Specifically, with reference to Equation (1), legitimate instruments include  $I_{it}/K_{i(t-1)}$ ,  $Q_{it}$ , and  $CF_{it}/K_{i(t-1)}$  all lagged twice or more<sup>15</sup>.

Consistency of the GMM estimates depends on the validity of the instruments. We test for the validity of our instruments by using two tests suggested by Arellano and Bond (1991): the  $J$  test and the test for second-order serial correlation of the residuals ( $m2$ ). The former is the Sargan test for overidentifying restrictions, asymptotically distributed as a chi-square with degrees of freedom equal to the number of instruments less the number of parameters, under the null of instrument validity. The  $m2$  test is asymptotically distributed as a standard normal under the null of no second-order serial correlation, and provides a further check on the specification of the model and on the legitimacy of variables dated  $t-2$  as instruments.

#### 4. Main features of the data and descriptive statistics

##### *The data set*

The data used in this paper consist of UK quoted company balance sheets collected by Datastream. We consider only the manufacturing sector. Investment ( $I$ ) is measured as the purchase of fixed assets by the firm. Cash flow ( $CF$ ) is obtained as the sum of the firm's after-tax profits and depreciation. Our measure of the replacement value of capital stock ( $K$ ) is derived from the book value of the firm's stock of net fixed assets, using the investment data in a standard perpetual inventory formula.  $Q$  is calculated as the ratio between the sum of the market value of the firm and the firm's total debt and the replacement value of its capital stock. Precise definitions of all variables used in the paper are presented in Table 1.

We started with 11536 annual observations (1113 firms) over the period 1980-2000. We then excluded companies that changed the date of their accounting year-end by more than a few weeks, so that the data refer to 12 month accounting periods. Moreover, when GMM is used, equations are estimated in first-differences, and values of the regressors lagged twice or more are used as instruments. For this reason, considering that our estimating equation contains lagged variables, at least three cross-sectional observations are needed for each firm

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<sup>15</sup> The lag structure of the instruments in  $Q_{it}$  also helps to control for the time-varying component of the measurement error, which is likely to affect this variable (see Erickson and Whited, 2000; and Bond and Cummins, 2001, for a discussion of the measurement error likely to characterize  $Q$ ).

to allow the first-differencing process and the construction of the instruments. Thus, only firms with a minimum of three consecutive observations were kept in the sample. This left us with 10862 observations (955 firms). To control for the potential influence of outliers, we truncated the sample by removing observations beyond the 1<sup>st</sup> and 99<sup>th</sup> percentiles for each of the regression variables. We also excluded those observations characterized by an investment to capital stock ratio greater than one. These cut-offs are aimed at eliminating observations reflecting particularly large mergers, extraordinary firm shocks, or coding errors<sup>16</sup>. After these adjustments, we were left with 10143 observations on 902 firms<sup>17</sup>. We then dropped firm-years that did not have complete records on the variables used in our regressions, namely the investment to beginning-of-period capital stock ratio, the lagged investment to capital ratio, the cash flow to beginning-of-period capital stock ratio, lagged  $Q$ , the contracted capital expenditure to beginning-of-period capital stock ratio, and the total number of employees. This left us with a sample of 6308 observations for 693 firms over the period 1983-2000, which is the sample used for the OLS and Within Groups estimates<sup>18</sup>. As GMM is based on the estimation of Equations (1) and (6) in first-differences, only 5615 observations are used for the GMM estimates. Our sample has an unbalanced structure, with the number of years of observations on each firm varying between three and 18. By allowing for both entry and exit, the use of an unbalanced panel partially mitigates potential selection and survivor bias.

To test whether cash flow has a different impact on the investment of different types of firms, we partition firms according to whether they are more or less likely to face financing constraints using employees as a measure of size. In particular, we generate a dummy variable,  $SMALL_{it}$ , which is equal to 1 if firm  $i$  has less than 250 employees in year  $t$ , and 0, otherwise<sup>19</sup>. We allow firms to transit between size classes<sup>20</sup>. To check robustness, we will explore results for alternative cut-offs.

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<sup>16</sup> These types of sample selection rules are quite common in the literature and we employ them to ensure comparability with previous work (Bond et al., 2003; Cummins et al., 2006).

<sup>17</sup> It should be noted that after removing the outliers, some firms ended up with less than three consecutive observations, and had to be excluded for the sample.

<sup>18</sup> Once again, after removing those observations for which one or more of the regression variables were missing, some firms ended up with less than three consecutive observations, and had to be excluded from the sample.

<sup>19</sup> A firm with less than 250 employees is much smaller than a typical “small” US firm. However, this number is appropriate in a European context, where firms are typically smaller than in the US (see Bank of England, 2002, for a discussion of various definitions of small, medium, and large firms). Our results were robust to using the firms’ total real assets as a measure for size.

<sup>20</sup> For this reason, our empirical analysis will focus on firm-years rather than simply firms. See Bond and Meghir (1994), Kaplan and Zingales (1997), Guariglia and Schiantarelli (1998), and Guariglia (2000) for a similar approach.

*The contracted capital expenditure variable*

The contracted capital expenditure variable (*CONK*), which we use as our new proxy for expectations, reflects the insiders' evaluation of investment opportunities. It is defined as contracts entered into for the future purchase of capital items, expenditure on machinery, equipment, plant, vehicles, and buildings, for which nothing has been paid by balance sheet date. Every year, firms are required to provide this information together with their Financial Statements, following paragraph 50(3) of the Fourth Schedule to the Companies Act 1985, as amended by the Companies Act 1989 and Statutory Instrument 1996 189. Contracted capital expenditure has to be reported in the Notes to the firms' Financial Statements, generally under the heading "Capital Commitments". These Notes are added at the end of the firms' Financial Statements: they help explain the computation of specific items in the Financial Statements and provide a more comprehensive assessment of companies' financial conditions<sup>21</sup>. Contracted capital expenditure is likely to transform itself into actual investment in the subsequent year, or in subsequent years if the contracts are long-term. Even if the contracts are broken, the variable still contains information about managers' forecasts of investment opportunities.

Although contracted capital expenditure is unlikely to be a complete measure of the managers' expectations of future investment demand, as typically firms do not contract their entire expected future investment ahead of time, it is still reasonable to interpret this variable as an insider's expectation of future investment demand. We believe that proxying the firm's investment opportunities with outsiders' evaluation of these opportunities (*Q*), along with our measure of the firm's insiders' expectations of future investment demand gives a more comprehensive assessment of the overall investment opportunities of the firm, than *Q* alone. Including *CONK* in our investment regressions should therefore reduce the chance that cash flow is significant only because it is correlated with investment opportunities not captured in *Q*.

Being a direct measure of the firm's managers' (insiders') expected future returns, our contracted capital expenditure variable differs from the analysts' (outsiders') future earnings forecasts used by Bond and Cummins (2001), Bond et al. (2004), and Cummins et al. (2006). It also differs from Gilchrist and Himmelberg's (1995) indirect measures of investment opportunities, which are derived from statistical methods. Contrary to these authors'

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<sup>21</sup> As contracted capital expenditure is reported together with the firms' Financial Statements at the end of each year, it can only be observed by outside investors and analysts at annual intervals.

measures of investment opportunities, our measure is not a substitute, but a complement to Tobin's  $Q$ . Measuring the firm's investment opportunities in this "extended" way may therefore reduce the likelihood that cash flow picks up investment opportunities in our investment regressions.

### *Summary statistics*

Table 2 reports some descriptive statistics for the full sample and for the sub-samples of firm-years with high and low employment. The first column of figures presents variable means for the full sample, whereas columns (2) and (3) respectively refer to small and large firm-years. The average firm-year has 5225.6 employees, whereas the average large firm-year has 6217.4 employees, and the average small firm-year has 149.5 employees. Compared to large firm-years, small firm-years generally have lower investment, cash flow, contracted capital expenditure, and sales growth. For the small firm-years the investment to capital ratio is in fact 0.14, whereas it is 0.17 for the large ones. The corresponding figures for the cash flow to capital ratio are 0.23 and 0.29; for the contracted capital expenditure to capital ratio, 0.02 and 0.03; and for sales growth, 6.30 and 8.75. In contrast, small firm-years have a larger  $Q$  (4.11) than high employment-firm years (3.15). The Table also shows that contracted capital expenditure is a meaningful part of actual capital expenditure for both small and large firm-years: the contracted capital expenditure to investment ratio is in fact equal to 0.20 for the former and to 0.22 for the latter firm-years. The standard deviation of the same ratio is 0.75 for small firm-years and 0.64 for large firm-years, suggesting bigger variations in the predictive power of contracted capital expenditure for the former.

## **5. Estimation results**

### *Baseline results*

Table 3 presents the estimates of Equation (1) for the full sample of firms. Column (1) reports the OLS estimates<sup>22</sup>. The coefficients on the three regressors are statistically significant. In particular, cash flow is positively associated with investment. The point estimate (0.094) indicates that the elasticity of investment with respect to cash flow, evaluated at sample means, is 0.162. A 10 percent increase in the cash flow to capital ratio leads therefore to a 1.62 percent increase in investment. The  $R^2$  suggests that 41 percent of the total variance of the investment to capital ratio is explained by the model.

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<sup>22</sup> These estimates, as well as the pooled IV estimates, are adjusted for clustering.

As discussed in Section 3, the OLS estimates are however likely to suffer from biases due to unobserved heterogeneity, and possible endogeneity of the regressors. Column (2) reports the estimates obtained using the Within Groups estimator, which controls for the former bias. The  $\rho$  coefficient, which represents the proportion of the total error variance accounted for by unobserved heterogeneity is equal to 0.31. This suggests that it is important to take unobserved firm-specific characteristics into account. The coefficient on the lagged dependent variable (0.171) is much smaller than the corresponding coefficient obtained in the OLS specification (0.336), which was obviously biased. The coefficient on cash flow is once again positive and precisely determined.

Since the OLS specification reported in column (1) may also be biased due to the endogeneity of the contemporaneous cash flow variable, we report the results based on a pooled IV specification in column (3), where the instrument set is made up of the investment to capital ratio,  $Q$ , the cash flow to capital ratio, real sales, and employment, all lagged once. In this specification, we can see that cash flow still has a positive and significant effect on investment. The  $J$ -statistic suggests that the instruments are valid<sup>23</sup>.

The specifications reported in columns (2) and (3) however, only take into account the two biases characterising the OLS specification individually. In column (4) of Table 3, we present therefore the results of the estimation of our investment equation undertaken using a Within Groups Instrumental Variables estimator, which takes the two biases simultaneously into account, and uses the same instruments as in column (3). Once again, all three regressors attract positive and precisely determined coefficients. The point estimate of the cash flow coefficient is 0.11, higher than the other three estimates previously discussed. It suggests that a 10 percent increase in cash flow leads to a 1.94 percent rise in investment. The  $R^2$  suggests that circa 36 percent of the total variance of the investment to capital ratio is explained by the model.

Finally, in column (5) of Table 3, we present the estimates obtained with our preferred estimator, namely the first-difference GMM estimator. Our instrument set includes  $I_{it}/K_{i(t-1)}$ ,  $Q_{it}$ ,  $CF_{it}/K_{i(t-1)}$ , real sales, and employment, all lagged two and three times. The estimated coefficient on the lagged dependent variable lies between the corresponding estimates obtained using OLS and the Within Groups estimator. This suggests that our GMM estimator

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<sup>23</sup> The  $J$  statistic is obtained by regressing the IV equations' residuals upon all the instruments and calculating the statistic  $nR_u^2$ , where  $n$  is the number of observations and  $R_u^2$  is the uncentered  $R^2$ . Under the null hypothesis that all instruments are orthogonal to the error term, this statistic is distributed as a  $\chi^2$  with degrees of freedom equal to the number of overidentifying restrictions (Baum et al., 2003).

is unlikely to suffer from a weak instrument bias (see Bond et al., 2001)<sup>24</sup>. Once again, the coefficient on the cash flow variable is positive and statistically significant. The point estimate (0.099) indicates that the elasticity of investment with respect to cash flow evaluated at sample means is 0.155, suggesting that a 10 percent rise in cash flow is associated with a 1.55 percent increase in investment. The coefficients associated with the lagged dependent variable,  $Q$ , and cash flow are comparable to those obtained in previous studies that focused on investment behavior in the UK (see Devereux and Schiantarelli, 1990; Blundell et al., 1992; Bond et al., 2004). The  $J$  and  $m2$  statistics suggest that the instruments are valid and that there is no gross mis-specification in the model. The GMM first-differenced estimator will be used in the estimation of all the specifications to follow.

All the specifications reported in Table 3 indicate that there is a positive relationship between cash flow and investment, similar to results obtained in previous studies for the UK and other countries. It is also important to note that the point estimates for cash flow are quantitatively robust to the choice of estimator. But is this positive correlation caused by information asymmetries in capital markets that may lead to financing constraints, or by the relationship between cash flow and investment opportunities not captured by  $Q$ ?

#### *Introducing contracted capital expenditure and allowing for firm heterogeneity*

We now estimate the following more general regression denoting the firm's contracted capital expenditure as  $CONK$ :

$$I_{it}/K_{i(t-1)} = a_0 + a_1 I_{i(t-1)}/K_{i(t-2)} + a_2 Q_{i(t-1)} + a_3 CF_{it}/K_{i(t-1)} + a_4 CONK_{it}/K_{i(t-1)} + \text{error term} \quad (6)$$

Contracted capital expenditure is measured at end of period, and captures expectations of future profits known to insiders, which are not included in beginning of period  $Q$ . Adding this variable to our investment specifications alongside  $Q$  is likely to ensure that both the insiders' and the outsiders' evaluations of investment opportunities are accounted for in the regression. Including contracted capital expenditure should reduce the size of the cash flow coefficient if cash flow contains omitted expectations of investment demand. If the cash flow term remains statistically significant, then this is likely to be due to information asymmetries in capital markets, leading to financing constraints.

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<sup>24</sup> For this reason, we do not report the estimates obtained using the system-GMM estimator developed in Blundell and Bond (1998). These, however, are available from the authors upon request.

Column (1) of Table 4 presents the GMM estimates of our extended investment model for the aggregate sample. We can see that the coefficient on  $CONK_{it}/K_{i(t-1)}$  is positive and both statistically and economically significant: contracted capital expenditure clearly has information about firm investment embedded in it. Since the coefficient estimate on the  $Q$  variable is similar to that reported in column (5) of Table 3, one can conclude that the variation of  $Q$  and  $CONK$  is largely orthogonal and that the information in  $CONK$  is not contained in  $Q$ . It also appears that the coefficient on the cash flow variable remains statistically significant, but drops from 0.089 in the model without contracted capital expenditure to 0.079 in the extended model. The fact that cash flow remains positively associated with investment, even after controlling for investment opportunities, considering both the outsiders' and the insiders' evaluation of these opportunities, suggests that it might play a role in capturing the severity of financial constraints.

If financial factors drive the positive relationship between cash flow and investment, then one would expect this relationship to be stronger for those firms more likely to face financial constraints. We estimate our investment equation interacting all the right hand side variables with the dummies  $SMALL_{it}$  and  $(1-SMALL_{it})$ . This formulation allows the parameters of the model to differ across observations in the two sub-samples. We initially estimate the model including only lagged investment,  $Q$ , and cash flow, all interacted with the dummies  $SMALL_{it}$  and  $(1-SMALL_{it})$ . Our instrument set includes the interactions of  $I_{it}/K_{i(t-1)}$ ,  $Q_{it}$ , and  $CF_{it}/K_{i(t-1)}$  with the size dummies, and real sales and employments, all lagged twice.

The results are reported in column (2) of Table 4. Cash flow is positively and significantly associated with investment, for both small and large firm-years. The Table reports the  $p$ -value associated with an  $F$ -test aimed at assessing whether the impact of cash flow on investment is the same for small and large firm-years. Although the hypothesis cannot be rejected, the coefficient is larger for small firm-years: the elasticities evaluated at sample means suggest that a 10 percent rise in cash flow is associated with a 1.44 percent increase in investment for small firm-years, and with a 1.28 percent increase for large firm-years. This supports the hypothesis that financial variables positively affect investment as a consequence of capital market imperfections. It should be noted, however, that in this particular specification, cash flow could also proxy for investment opportunities. The  $J$  and



$m2$  tests do not indicate any problems with the specification of the model and the choice of the instruments<sup>25</sup>.

Our next specification includes contracted capital expenditure interacted with the size dummies as additional regressors to improve the measurement of investment opportunities. The GMM estimates of this extended model are presented in column (3) of Table 4. The coefficient on cash flow for large firm-years is now much smaller than in the previous specification and no longer significant at the 5 percent level. On the other hand, the corresponding coefficient for small firm-years remains precisely determined and rises slightly: it suggests that a 10 percent rise in cash flow is associated with a 1.6 percent rise in investment<sup>26</sup>. The coefficient on the contracted capital expenditure variable is statistically significant and economically important for both types of firm-years: it is equal to 1.39 for large firm-years, and to 0.64 for small firm-years. This confirms that contracted capital expenditure has information about firm investment embedded in it. In addition, the coefficient estimates on the  $Q$  variables are similar between columns (2) and (3), suggesting once again that the information in  $CONK$  is not contained in  $Q$ . As in the previous specification, the  $J$  and  $m2$  tests do not indicate any problems with the specification of the model or the choice of the instruments.

To formally test whether the inclusion of the contracted capital expenditure variables improves the specification of our investment model, we present a test of the extended investment model (which includes the contracted capital expenditure variables) versus the parsimonious one (without contracted capital expenditure variables)<sup>27</sup>. This test involves the construction of the chi-squared statistic suggested by Newey and West (1987). If a model is incorrectly specified, the  $J$  test for that model will tend to be relatively large. The difference in the  $J$  statistics between the model with and without the contracted capital expenditure variables, holding the weighting matrix fixed can be seen as a test of whether the improvement of specification which takes place when contracted capital expenditure is added is statistically significant<sup>28</sup>. The difference between the two  $J$  statistics is distributed as a chi-

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<sup>25</sup> Similar results, not reported for brevity, but available from the authors upon request, were obtained if separate regressions were estimated for small and large firms using either the average number of employees over the sample period, or the pre-sample number of employees as sample separation criteria.

<sup>26</sup> Although, according to our  $F$ -test, the difference in magnitude between the cash flow coefficient at small and large firm-years is not statistically significant, the latter coefficient is no longer precisely determined.

<sup>27</sup> The null hypothesis is that the parsimonious model is acceptable, i.e. that there is no significant improvement in the specification of the model once the contracted capital expenditure variables are added.

<sup>28</sup> The instruments that we chose provide a set of moment restrictions of the following type:  $E(Z_{it}^j e_{it}) = 0$ , where  $Z_{it}^j$  is the  $j$ -th instrument for firm  $i$  in year  $t$ , and  $e_{it}$  is the idiosyncratic error term. The GMM estimator minimizes a quadratic form, in the corresponding sample moments, using a weighting matrix given by a

squared with two degrees of freedom<sup>29</sup>. The Newey-West statistic is in our case 2134.46, which is obviously statistically significant. This shows that there is a clear improvement in the specification of our investment model if contracted capital expenditure is added (also see Ng and Schaller, 1996, who make use of a similar test).

Our results suggest that for large firms, there is some evidence that the positive association between cash flow and investment in the model that only includes lagged investment,  $Q$ , and cash flow as explanatory variables is caused by the correlation between cash flow and investment opportunities that are not properly captured by  $Q$ . The association becomes in fact weaker once the contracted capital expenditure variables are included in the regression. On the other hand, for small firms, the relationship between cash flow and investment is more likely to be caused by information asymmetries in the capital markets. Once the contracted capital expenditure variables are introduced in the model, cash flow remains in fact statistically significant, and its coefficient does not significantly drop. This can be seen as evidence in favor of the controversial hypothesis that financing constraints play a crucial role in explaining the positive link between cash flow and investment.

### *Robustness checks*

A number of researchers who participated to the debate on the role of cash flow in explaining investment estimated specifications which did not include the lagged dependent variable as a regressor (see FHP, 1988; Kaplan and Zingales, 1997 etc.). To better compare our study and theirs, we estimated a GMM investment equation similar to that in column (3) of Table 4, but excluding the variables involving the lagged investment to capital ratio both from the set of regressors and from the instrument set. The results of this new specification are reported in column (1) of Table 5. Similarly to the specification in column (3) of Table 4, the coefficient on cash flow is only significant for small firm-years, and the coefficient on the contracted capital expenditure variable is significant for both small (at the 10 percent significance level) and large (at the 5 percent level) firm-years. In spite of these similarities, the  $J$  test only has a marginal significance of 0.034, suggesting that the omission of the lagged dependent variable causes mis-specification in the model.

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consistent estimate of the variance-covariance matrix of the moment restrictions themselves. See Arellano and Bond (1998) for more details.

<sup>29</sup> More in general, the degrees of freedom of the  $\chi^2$  statistic are given by the number of omitted parameters in the parsimonious model. Since the two models that we are comparing differ only by the presence of the two variables in contracted capital expenditure, we consider a  $\chi^2$  statistic with two degrees of freedom.

Furthermore, we tested the robustness of our results to different criteria for splitting the sample between firm-years more and less likely to face financial constraints. Our main criterion defines in fact a firm as small in a given year if its total number of employees in that year is less than or equal to 250. We have tried to use other benchmark employment levels to classify firms into small and large, namely 200 and 300. As shown in columns (2) and (3) of Table 5, this has left our main results largely unchanged. Column (4) further shows that our results are robust to classifying firm  $i$  as small in year  $t$  if its total number of employees falls in the bottom quartile of the distribution of the number of employees of all firms operating in the same industry as firm  $i$  in year  $t$ , and as large otherwise.

As a further robustness test, in column (5) of Table 5, we replaced the end-of-period contracted capital expenditure variable interacted with the size dummies with the same variable evaluated at the beginning of the period. Although in this case there might be some overlap in the information contained in the latter variable and  $Q$ , evaluating both variables at time  $t-1$  ensures that the information sets of managers and market are at least potentially the same. The results are again qualitatively similar to those reported in column (3) of Table 4. The coefficient associated with cash flow is precisely determined for both small and large firm-years, but larger for the former.

Finally, in column (6) of Table 5, we re-estimated our main investment model using a broader sample, which includes those observations with a ratio of investment to capital greater than one. Once again, the coefficient associated with cash flow is statistically significant (at the 5 percent level) only for small firm-years. On the other hand, the contracted capital expenditure variable now only attracts a precisely determined coefficient for large firm-years.

Once the firms' investment opportunities are accounted for in a more comprehensive way by including the contracted capital expenditure variables in the regression (in addition to  $Q$ ) the explanatory power of cash flow falls for large firms but remains unchanged for small firms. Overall our results support the view that the investment of small firms is constrained by access to internal finance, while this is not the case for large firms.

## 6. Conclusion

This paper sheds light on the controversial role played by cash flow in investment regressions. The debate is centred around understanding whether cash flow is an important determinant of investment because of its role in alleviating credit frictions or because it proxies for omitted or mis-measured investment opportunities.

We used a panel of 693 UK firms over the period 1983-2000 to estimate investment equations as a function of lagged investment,  $Q$ , cash flow, and contracted capital expenditure. We argued that because in the presence of asymmetric information, gaps are likely to exist between the information sets of the firm's insiders and outsiders,  $Q$  is an imperfect measure of the firm's investment opportunities, as it only captures the equity market participants' (outsiders') evaluation of these opportunities. To improve the measurement of investment opportunities, we included the firm's contractual obligations for future new investment projects as an additional proxy. This variable is important as it captures information about opportunities available only to insiders and thus not measured in  $Q$ . Introducing it in our investment regressions alongside  $Q$  indeed improves the degree to which investment opportunities are measured. We found that when  $Q$  and the firm's contracted capital expenditure variable were both included in our regressions, the explanatory power of cash flow fell for large firms, but remained unchanged for small firms. Our results suggest that while cash flow may contain information about investment opportunities not captured in  $Q$ , the significance of cash flow in investment equations stems from its role in capturing the effect of credit frictions.

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**Table 1: Definitions of the variables used**

Variable name	Definition
Investment ( <i>I</i> )	<p><i>Up to 1991 (included):</i> v431: fixed assets purchased by the company excluding assets acquired from new subsidiaries.</p> <p><i>After 1991:</i> v1024: cash paid by the company towards the purchase of fixed assets (property, plant or equipment).</p>
Depreciation ( <i>dep</i> )	<p>We use rates of 8.19 percent for plant and machinery, and 2.5 percent for land and buildings (King and Fullerton, 1984).</p> <p>For each observation, we then calculate the proportion of land and building investment, as follows:  <math display="block">\frac{[\text{gross book value of all land and building (v327) - accumulated depreciation on land and building (v335)}]}{[\text{gross total fixed assets (v330) - accumulated depreciation of total fixed assets (v338)}]}</math> </p> <p><i>Mprlb</i>: average value of this ratio for each firm.</p> <p><math>dep = 0.0819 \cdot (1 - mprlb) + 0.025 \cdot mprlb</math></p>
Replacement value of the capital stock ( <i>K</i> )  calculated using the perpetual inventory formula (Blundell et al., 1992; Bond and Meghir, 1994).	<p>We use v339=tangible fixed assets (net) as the historic value of the capital stock.</p> <p>We assume that replacement cost and historic cost are the same in the first year of data for each firm.</p> <p>We then apply the perpetual inventory formula as follows: <math>K_{t+1} = K_t(1-dep) \cdot (p_{t+1}/p_t) + I_{t+1}</math>, where:  <math>p_t</math>: price of investment goods, proxied with the implicit deflator for gross fixed capital formation.</p>
Cash flow ( <i>CF</i> )	<p>v623+v136, where: v623: published after tax profit v136: depreciation.</p>
Contracted capital expenditure ( <i>CONK</i> )	v292: contracts entered into for the future purchase of capital items, expenditure on machinery, equipment, plant, vehicles and buildings.
Tobin's Q ( <i>Q</i> )	<p>(v1504 + v309+ v321)/replacement value of capital stock, where: v1504: enterprise value of the firm v309: borrowings repayable within one year v321: total loan capital repayable after one year.</p>
Total number of employees ( <i>Emp</i> )	v219: average number of employees as disclosed by the company.
Sales ( <i>Sales</i> )	v104: amount of goods and services to third parties relating to the normal industrial activities of the company.

*Note:* Datastream variables are indicated with vxxx.

**Table 2: Descriptive statistics**

	All firm-years	Firm-years such that $SMALL_{it}=1$	Firm-years such that $SMALL_{it}=0$
	(1)	(2)	(3)
<i>Number of employees</i>	5225.623 (14014.91)	149.544 (64.27)	6217.368 (15125.49)
$I_{it} / K_{i(t-1)}$	0.163 (0.13)	0.145 (0.15)	0.167 (0.13)
$Q_{it}$	3.303 (4.13)	4.107 (5.71)	3.146 (3.72)
$CF_{it} / K_{i(t-1)}$	0.281 (0.36)	0.231 (0.48)	0.291 (0.33)
$CONK_{it} / K_{i(t-1)}$	0.030 (0.05)	0.019 (0.05)	0.032 (0.05)
$CONK_{it} / I_{it}$	0.213 (0.64)	0.197 (0.75)	0.216 (0.62)
<i>Sales growth<sub>it</sub></i>	8.353 (31.35)	6.305 (34.37)	8.753 (30.71)
Number of observations	6308	1031	5277
Number of firms	693		

*Notes:* The table reports sample means. Standard deviations are presented in parentheses. The subscript  $i$  indexes firms, and the subscript  $t$ , time, where  $t=1983-2000$ .  $SMALL_{it}$  is a dummy variable equal to 1 if firm  $i$  has 250 employees or less at time  $t$ , and equal to 0 otherwise.  $I$  represents the firm's investment;  $K$ , the replacement value of its capital stock;  $Q$ , Tobin's  $Q$ ;  $CF$ , its cash flow; and  $CONK$ , its contracted capital expenditure.

**Table 3: The effects of cash flow on investment: alternative estimators**

Dependent Variable: $I_{it}/K_{i(t-1)}$	OLS (pooled)	Within Groups	IV (pooled)	Within Groups IV	First- diff. GMM
	(1)	(2)	(3)	(4)	(5)
$I_{i(t-1)}/K_{i(t-2)}$	0.336*** (0.019)	0.171*** (0.010)	0.365*** (0.012)	0.162*** (0.012)	0.206*** (0.029)
$Q_{i(t-1)}$	0.003*** (0.001)	0.008*** (0.0005)	0.002*** (0.002)	0.007*** (0.001)	0.009** (0.002)
$CF_{it}/K_{i(t-1)}$	0.094*** (0.008)	0.102*** (0.005)	0.108*** (0.011)	0.111*** (0.006)	0.089*** (0.003)
Sample size	6308	6308	5615	5615	5615
$R^2$	0.413	0.376	0.402	0.357	
$\rho$		0.315		0.375	
$m2$					-1.38
$J$ (p-value)			0.054	0.051	0.357

*Notes:* The figures reported in parentheses are asymptotic standard errors. Time dummies were included in all specifications. The specification in column (5) also contains time dummies interacted with industry dummies. Standard errors and test statistics are asymptotically robust to heteroskedasticity.  $\rho$  represents the proportion of the total error variance accounted for by unobserved heterogeneity.  $m2$  is a test for second-order serial correlation in the first-differenced residuals, asymptotically distributed as  $N(0,1)$  under the null of no serial correlation. The  $J$  statistic is a test of the overidentifying restrictions, distributed as chi-square under the null of instrument validity. Instruments in columns (3) and (4) are  $I_{it}/K_{i(t-1)}$ ,  $Q_{it}$ ,  $CF_{it}/K_{i(t-1)}$ , real sales, and employment, all lagged once; and time dummies. Instruments in column (5) are  $I_{it}/K_{i(t-1)}$ ,  $Q_{it}$ ,  $CF_{it}/K_{i(t-1)}$ , real sales, and employment, all lagged two and three times; time dummies, and time dummies interacted with industry dummies. \* indicates significance at the 10% level. \*\* indicates significance at the 5% level. \*\*\* indicates significance at the 1% level. Also see *Notes* to Table 2.

**Table 4: Introducing contracted capital expenditure and differentiating between small and large firm-years**

Dependent Var.: $I_{it}/K_{it(t-1)}$	First-diff. GMM	First-diff. GMM	First-diff. GMM
	(1)	(2)	(3)
$I_{it(t-1)}/K_{it(t-2)}$	0.137*** (0.027)		
$(I_{it(t-1)}/K_{it(t-2)}) * SMALL_{it}$		0.136* (0.07)	0.122* (0.067)
$(I_{it(t-1)}/K_{it(t-2)}) * (1 - SMALL_{it})$		0.215*** (0.033)	0.103*** (0.032)
$Q_{it(t-1)}$	0.010*** (0.003)		
$Q_{it(t-1)} * SMALL_{it}$		0.011*** (0.003)	0.011*** (0.003)
$Q_{it(t-1)} * (1 - SMALL_{it})$		0.009*** (0.003)	0.010*** (0.003)
$CF_{it}/K_{it(t-1)}$	0.079*** (0.022)		
$(CF_{it}/K_{it(t-1)}) * SMALL_{it}$		0.086** (0.036)	0.096*** (0.033)
$(CF_{it}/K_{it(t-1)}) * (1 - SMALL_{it})$		0.073*** (0.023)	0.048* (0.026)
$CONK_{it}/K_{it(t-1)}$	1.228*** (0.252)		
$(CONK_{it}/K_{it(t-1)}) * SMALL_{it}$			0.644** (0.305)
$(CONK_{it}/K_{it(t-1)}) * (1 - SMALL_{it})$			1.389*** (0.257)
$H_0$ : Impact of $CF_{it}/K_{it(t-1)}$ on $I_{it}/K_{it(t-1)}$ same across small and large firm-years ( $p$ -value)		0.776	0.257
Sample size	5615	5615	5615
$m2$	1.864	-1.456	1.684
$J$ ( $p$ -value)	0.091	0.402	0.095

Notes:  $SMALL_{it}$  is a dummy variable equal to 1 if firm  $i$  has 250 employees or less at time  $t$ , and equal to 0 otherwise. Instruments in column (1) are  $I_{it}/K_{it(t-1)}$ ,  $Q_{it}$ ,  $CF_{it}/K_{it(t-1)}$ ,  $CONK_{it}/K_{it(t-1)}$ , real sales, and employment, all lagged two and three times. Instruments in column (2) are  $(I_{it}/K_{it(t-1)}) * SMALL_{it}$ ,  $(I_{it}/K_{it(t-1)}) * (1 - SMALL_{it})$ ,  $Q_{it} * SMALL_{it}$ ,  $Q_{it} * (1 - SMALL_{it})$ ,  $(CF_{it}/K_{it(t-1)}) * SMALL_{it}$ ,  $(CF_{it}/K_{it(t-1)}) * (1 - SMALL_{it})$ , real sales, and employment, all lagged twice. Instruments in column (3) are  $(I_{it}/K_{it(t-1)}) * SMALL_{it}$ ,  $(I_{it}/K_{it(t-1)}) * (1 - SMALL_{it})$ ,  $Q_{it} * SMALL_{it}$ ,  $Q_{it} * (1 - SMALL_{it})$ ,  $(CF_{it}/K_{it(t-1)}) * SMALL_{it}$ ,  $(CF_{it}/K_{it(t-1)}) * (1 - SMALL_{it})$ ,  $(CONK_{it}/K_{it(t-1)}) * SMALL_{it}$ ,  $(CONK_{it}/K_{it(t-1)}) * (1 - SMALL_{it})$ , real sales, and employment, all lagged twice. Time dummies and time dummies interacted with industry dummies were always included in the specifications and the instrument set. The numbers in the rows testing whether the impact of  $CF_{it}/K_{it(t-1)}$  on  $I_{it}/K_{it(t-1)}$  is the same across small and large firm-years are the  $p$ -values associated with  $F$  tests for general restrictions. \* indicates significance at the 10% level. \*\* indicates significance at the 5% level. \*\*\* indicates significance at the 1% level. Also see Notes to Tables 2 and 3.

**Table 5: Robustness checks**

Dependent Var.: $I_{it} / K_{i(t-1)}$	Not including the lagged dependent variable	$SMALL_{it}=1$ if $emp_{it} \leq 200$	$SMALL_{it}=1$ if $emp_{it} \leq 300$	$SMALL_{it}=1$ if $emp_{it}$ falls in the first quartile of the distrib.	Including lagged $CONK$	Including firms with $I_{it} / K_{i(t-1)} > 1$
	(1)	(2)	(3)	(4)	(5)	(6)
$(I_{i(t-1)} / K_{i(t-2)}) * SMALL_{it}$	...	0.215*** (0.070)	0.121* (0.064)	0.160*** (0.045)	0.057 (0.080)	0.141*** (0.041)
$(I_{i(t-1)} / K_{i(t-2)}) * (1 - SMALL_{it})$	...	0.100*** (0.032)	0.117*** (0.032)	0.112*** (0.035)	0.080*** (0.029)	0.195*** (0.030)
$Q_{i(t-1)} * SMALL_{it}$	0.011*** (0.003)	0.011*** (0.004)	0.011*** (0.003)	0.010*** (0.003)	0.010*** (0.003)	0.017*** (0.003)
$Q_{i(t-1)} * (1 - SMALL_{it})$	0.011*** (0.003)	0.013*** (0.004)	0.012*** (0.003)	0.013*** (0.003)	0.008*** (0.003)	0.014*** (0.003)
$(CF_{it} / K_{i(t-1)}) * SMALL_{it}$	0.099*** (0.035)	0.077** (0.031)	0.087*** (0.030)	0.076** (0.035)	0.129** (0.037)	0.117*** (0.040)
$(CF_{it} / K_{i(t-1)}) * (1 - SMALL_{it})$	0.043 (0.029)	0.030 (0.028)	0.041 (0.028)	0.037 (0.025)	0.094*** (0.023)	0.059* (0.033)
$(CONK_{it} / K_{i(t-1)}) * SMALL_{it}$	0.590* (0.329)	0.337 (0.236)	0.968** (0.415)	1.388*** (0.484)	...	0.106 (0.400)
$(CONK_{it} / K_{i(t-1)}) * (1 - SMALL_{it})$	1.353*** (0.255)	1.594*** (0.311)	1.425*** (0.252)	1.339*** (0.263)	...	1.049*** (0.253)
$(CONK_{i(t-1)} / K_{i(t-2)}) * SMALL_{it}$	...	...	...	...	0.632*** (0.164)	...
$(CONK_{i(t-1)} / K_{i(t-2)}) * (1 - SMALL_{it})$	...	...	...	...	0.761*** (0.067)	...
Sample size	5615	5615	5615	5615	5574	5844
$m2$	-0.218	1.954	1.925	0.05	-2.060	1.742
$J(p\text{-value})$	0.034	0.146	0.072	0.241	0.314	0.111

Notes:  $Emp_{it}$  represents the number of workers employed at firm  $i$  at time  $t$ . Unless otherwise stated,  $SMALL_{it}$  is a dummy variable equal to 1 if firm  $i$  has 250 employees or less at time  $t$ , and equal to 0 otherwise. All specifications were estimated using a first-difference GMM estimator. Instruments in column (1) are  $Q_{it} * SMALL_{it}$ ,  $Q_{it} * (1 - SMALL_{it})$ ,  $(CF_{it} / K_{i(t-1)}) * SMALL_{it}$ ,  $(CF_{it} / K_{i(t-1)}) * (1 - SMALL_{it})$ ,  $(CONK_{it} / K_{i(t-1)}) * SMALL_{it}$ ,  $(CONK_{it} / K_{i(t-1)}) * (1 - SMALL_{it})$ , real sales, and employment, all lagged twice. Instruments in columns (2) to (5) are  $(I_{it} / K_{i(t-1)}) * SMALL_{it}$ ,  $(I_{it} / K_{i(t-1)}) * (1 - SMALL_{it})$ ,  $Q_{it} * SMALL_{it}$ ,  $Q_{it} * (1 - SMALL_{it})$ ,  $(CF_{it} / K_{i(t-1)}) * SMALL_{it}$ ,  $(CF_{it} / K_{i(t-1)}) * (1 - SMALL_{it})$ ,  $(CONK_{it} / K_{i(t-1)}) * SMALL_{it}$ ,  $(CONK_{it} / K_{i(t-1)}) * (1 - SMALL_{it})$ , real sales, and employment, all lagged twice. Instruments in column (6) are  $(I_{it} / K_{i(t-1)}) * SMALL_{it}$ ,  $(I_{it} / K_{i(t-1)}) * (1 - SMALL_{it})$ ,  $Q_{it} * SMALL_{it}$ ,  $Q_{it} * (1 - SMALL_{it})$ ,  $(CF_{it} / K_{i(t-1)}) * SMALL_{it}$ ,  $(CF_{it} / K_{i(t-1)}) * (1 - SMALL_{it})$ ,  $(CONK_{it} / K_{i(t-1)}) * SMALL_{it}$ ,  $(CONK_{it} / K_{i(t-1)}) * (1 - SMALL_{it})$ , real sales, and employment, all lagged two and three times. Time dummies and time dummies interacted with industry dummies were always included in the specification and the instrument set. \* indicates significance at the 10% level. \*\* indicates significance at the 5% level. \*\*\* indicates significance at the 1% level. Also see Notes to Tables 2 and 3.